

## GOLF BALL FORMED FROM A POLYISOCYANATE COPOLYMER AND METHOD OF MAKING SAME

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### Cross References to Related Applications

This application is a continuation-in-part application of U.S. Patent Application Serial No. 09/877,600 filed June 8, 2001, which is a continuation of U.S. Application Serial No. 09/411,690 filed October 1, 1999 and issued as U.S. Patent No. 6,290,614 on September 18, 2001, which is a continuation-in-part of  
10 U.S. Patent Application Serial No. 09/040,798 filed March 18, 1998.

### Field of the Invention

The present invention relates generally to golf balls containing a  
15 fast-chemical-reaction-produced component formed, in part, from a polyisocyanate copolymer. More particularly, the golf balls contain a fast-chemical-reaction-produced component formed from a reactant, such as a polyol, and an aliphatic/aromatic isocyanate copolymer. Preferably, the copolymer is an isocyanate copolymer of toluene diisocyanate and  
20 hexamethylene diisocyanate. The component formed by the fast-chemical-reaction can be utilized to form the core, intermediate layer(s) and/or cover layer(s) of a golf ball. Each of the core, intermediate and/or cover layers may include one or more different layers.

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### Background of the Invention

Commercial golf balls today consist generally of three types of configurations. The first type is a multi-piece, wound ball in which a vulcanized rubber thread is wound under tension around a solid or semi-solid core, and thereafter enclosed in a single or multi-layer covering of a tough, protective  
30 material. A second type of a golf ball is a one-piece ball formed from a solid mass of resilient material which has been cured to develop the necessary degree of hardness to provide utility. A third type of ball is a multi-piece, non-

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wound ball that includes a liquid, gel or solid core of one or more layers and a cover having one or more layers formed over the core.

Conventional golf ball covers have been made of ionomer, balata, and slow-reacting, thermoset polyurethane materials. When polyurethane covers are made by conventional methods, such as by casting, a substantial amount of time and energy is required, thus resulting in relatively high cost. In addition, when producing one or more core and/or cover layers from polyurethane, other processing problems occur, including discoloration due to ultra-violet light, slower reaction times, and insufficient physical properties. Although satisfactory in some respects, a need exists for improved polyurethane formulations and methods of producing golf balls and components thereof.

It would be useful to develop a golf ball containing a fast-chemical-reaction-produced component, such as at least one core or cover layer, particularly one which contains polyurethane, polyurea, epoxy and/or unsaturated polyester.

It would also be useful to form a golf ball core, interior, or cover layer from a reaction injection molding system using a suitable cross-linker that provides little or no discoloration due to ultra-violet light, has fast reaction times, and exhibits good physical properties.

It would be particularly desirable to provide a multi-piece golf ball of the third type previously described utilizing the noted fast-chemical-reaction-produced component and/or the noted cross-linker.

Another object of the invention is to provide a method of making a golf ball of the type described above.

### **Summary of the Invention**

The present invention is directed to a method of making a golf ball component by reaction injection molding a polyisocyanate copolymer and at least one reactant. Preferably, the polyisocyanate copolymer is a copolymer of an aromatic isocyanate and an aliphatic isocyanate. Most preferably, the polyisocyanate copolymer is a copolymer of hexamethylene diisocyanate ("HDI")

and toluene diisocyanate ("TDI"). The golf ball component formed by reaction injection molding can be a core, mantle, or cover layer.

In an additional aspect, the present invention is directed to a method for making a golf ball component. The method comprises mixing a polyisocyanate copolymer and at least one reactant. The polyisocyanate copolymer and at least one reactant are chemically reacted to form a reaction mixture adapted for reaction injection molding. The reaction mixture is then molded to form a golf ball component.

In another aspect, the present invention is directed to a process for forming a golf ball component comprising polyurethane or polyurea by a reaction injection molding technique. The process includes mixing a polyisocyanate copolymer and reactant, such as a polyol, into a closed mold. The polyisocyanate copolymer is a copolymer of toluene diisocyanate and hexamethylene diisocyanate. The polyisocyanate copolymer and reactant are chemically reacted in the closed mold to form a reaction mixture. The reaction is molded in the closed mold to form a golf ball component.

In a further aspect, the present invention is directed to a method for making a polyurethane or polyurea covered golf ball. The method includes mixing a polyisocyanate copolymer, the polyisocyanate copolymer including toluene diisocyanate and hexamethylene diisocyanate, and a reactant such as a polyol. The polyisocyanate copolymer and reactant are chemically reacted to form a reaction mixture adapted for reaction injection molding. The reaction mixture is molded about a core, or a core with one or more intermediate layers, to form a polyurethane or polyurea covered golf ball.

In a still another aspect, the invention is directed to the use of a hexamethylene diisocyanate/toluene diisocyanate copolymer as a cross-linker for a polyurethane/polyurea reaction injection molded golf ball cover or mantle (i.e. intermediate or inner cover layer). The copolymer exhibits good light fastness, speed of reaction and physical properties.

Other objects of the invention will become apparent from the specification, drawings and claims.

### **Brief Description of the Drawings**

The following is a brief description of the drawings which are presented for the purposes of illustrating the invention and not for purposes of limiting the same.

5               FIG. 1 is a first embodiment of a golf ball formed according to a reaction injection molding (RIM) process according to the invention.

FIG. 2 is a second embodiment of a golf ball formed according to a reaction injection molding (RIM) process according to the invention.

10              FIG. 3 is a third embodiment of a golf ball formed according to a reaction injection molding (RIM) process according to the invention.

FIG. 4 is a process flow diagram which schematically depicts a reaction injection molding process according to the invention.

FIG. 5 schematically shows a mold for reaction injection molding a golf ball cover according to the invention.

15              FIG. 6 is a schematic illustration of a hitting chamber used to conduct durability tests.

FIG. 7 is a detailed view of a portion of an insert plate used in the hitting chamber shown in FIG. 6, which contains a series of grooves that contact a golf ball.

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### **Detailed Description of the Preferred Embodiments**

The preferred embodiment of the present invention is a golf ball in which at least one cover, mantle or core layer comprises a fast-chemical-reaction-produced component that is formed from a polyisocyanate copolymer.

25              The cover, mantle and/or core includes at least one material selected from the group consisting of polyurethane, polyurea, polyurethane ionomer, epoxy, and unsaturated polyesters, and preferably comprises polyurethane. The polyisocyanate copolymer is preferably a copolymer of hexamethylene diisocyanate and toluene diisocyanate.

30              The invention also includes a method of producing a golf ball which contains a fast-chemical-reaction-produced component formed by mixing a

polyisocyanate copolymer and at least one other reactant. A golf ball formed according to the invention preferably has a flex modulus in the range of from about 1 to about 310 kpsi, a Shore D hardness in the range of from about 10 to about 95, and good durability. Particularly preferred forms of the invention also  
5 provide for a golf ball with a fast-chemical-reaction-produced cover having good scuff resistance and cut resistance. As used herein, "polyurethane and/or polyurea" is expressed as "polyurethane/polyurea".

A particularly preferred form of the invention is a golf ball with a cover comprising polyurethane formed from a polyisocyanate copolymer,  
10 wherein the cover includes from about 5 to about 100 weight percent of polyurethane. More preferably, the polyurethane is formed from recycled polyurethane.

The method of the invention is particularly useful in forming golf balls because the method can be performed at relatively low temperatures and  
15 pressures. The preferred temperature range for the method is from about 90 to about 180°F when the component being produced contains polyurethane. Preferred pressures for the method when using polyurethane-containing materials are 200 psi or less and more preferably 100 psi or less.

The method of the present invention offers numerous advantages  
20 over conventional slow-reactive processes for the compression molding of golf ball covers. The present method produces molded covers in a mold release or demold time of 10 minutes or less, preferably 2 minutes or less, and most preferably in 1 minute or less. The present method also results in the formation of a reaction product, formed by mixing two or more reactants together, that  
25 exhibits a reaction time of about 2 minutes or less, preferably 1 minute or less, and most preferably about 30 seconds or less. An excellent finish can also be produced on the ball by using the present method.

The term "demold time" generally refers to the mold release time, which is the time span from the mixing of the components until the earliest  
30 possible time at which the part may be removed from the mold. At that time of removal, the part is said to exhibit sufficient "green strength." The term "reaction

time" generally refers to the setting time or curing time, which is the time span from the beginning of mixing until the time at which the product no longer flows. Further description of the terms setting time and mold release time are provided in the "Polyurethane Handbook," edited by Günter Oertel, Second Edition, ISBN 1-56990-157-0, herein incorporated by reference.

The method of the invention also is particularly effective when recycled polyurethane or other polymer resin, or materials derived by recycling polyurethane or other polymer resin, are incorporated into the product. The process may include the step of recycling at least a portion of the reaction product, preferably by glycolysis. From about 5% to about 100% of the polyurethane/polyurea formed from the reactants used to form particular components can be obtained from recycled polyurethane/polyurea.

As indicated above, the fast-chemical-reaction-produced component can be one or more cover, mantle and/or core layers of the ball. When a polyurethane cover is formed according to the invention, and then covered with a polyurethane top coat, excellent adhesion can be obtained. The adhesion in this case is better than adhesion of a polyurethane coating to an ionomeric cover. This improved adhesion enables the use of a thinner top coat, the elimination of a primer coat, and the use of a greater variety of golf ball printing inks beneath the top coat. These include, but are not limited to, typical inks such as one component polyurethane inks and two component polyurethane inks.

Polyisocyanates represent the key substances in forming polyurethane/polyurea. The general structure of polyisocyanates is  $R-(NCO)_n$ , where  $n$  is at least two, and  $R$  is an aromatic or an aliphatic group. The isocyanate groups ( $-N=C=O$ ) that react with hydroxyl groups form a polyurethane, whereas isocyanate groups that react with an amine group form a polyurea. In the present invention, the isocyanate groups (i.e., the "iso" side) may react with the hydroxyl group, the amine group, or both (i.e., the "polyol" side), in order to form polyurethane/polyurea.

Polyisocyanates suitable for the present invention are preferably diisocyanates selected from the group including, but not limited to, 4,4'-methylenebis(phenyl isocyanate) (MDI); toluene diisocyanate (TDI); m-xylylene diisocyanate (XDI); hexamethylene diisocyanate (HDI); methylene bis-(4-cyclohexyl diisocyanate) (HDMI); naphthalene -1,5,-diisocyanate (NDI); 3,3'-dimethyl -4,4'-biphenyl diisocyanate (TODI); 1,4-diisocyanate benzene (PPDI); phenylene-1, 4,4'-diisocyanate; trimethyl hexamethylene diisocyanate (TMDI); isophorone diisocyanate (IPDI); 1,4-cyclohexyl diisocyanate (CHDI); diphenylether-4,4'-diisocyanate; p,p'-diphenyl diisocyanate; lysine diisocyanate (LDI); 1,3-bis(isocyanate methyl) cyclohexane; polymethylene polyphenyl isocyanate (PMDI); and isomers thereof.

Preferably, the polyisocyanate of the present invention is a polyisocyanate copolymer. More preferably, the polyisocyanate copolymer is a blend of an aromatic isocyanate and an aliphatic isocyanate. Use of a polyisocyanate copolymer blend of an aromatic isocyanate and aliphatic isocyanate imparts advantageous properties of each isocyanate into the copolymer, including very good light fastness, good reaction speed, and excellent physical properties.

Aromatic isocyanates include, but are not limited to, toluene diisocyanate (TDI); diphenyl-methane-diisocyanate (MDI); naphthalene-1,5-diisocyanate (NDI); m- and p-phenylene diisocyanate; toluene-2,4- and -2,6-diisocyanate; diphenylmethane-4,4'-diisocyanate; chlorophenylene-2,4-diisocyanate; naphthylene-1,5-diisocyanate; 3-methyldiphenylmethane-4,4'-diisocyanate; 4,4'-diisocyanate-3,3'-dimethyldiphenyl; 3-methyldiphenylmethane-4,4'-diisocyanate and diphenyl ether diisocyanate. Generally, aromatic isocyanates exhibit fast reaction times and good physical properties, but tend to have poor light fastness (i.e., discoloration due to UV light).

Aliphatic isocyanates include, but are not limited to, hexamethylene diisocyanate (HDI); isophorone diisocyanate (IPDI); tetramethylene diisocyanate; octamethylene diisocyanate; decamethylene diisocyanate; dodecamethylene diisocyanate; tetradecamethylene diisocyanate; derivatives of lysine

diisocyanate; tetramethylxylylene diisocyanate; trimethylhexane diisocyanate or tetramethylhexane diisocyanate; cycloaliphatic diisocyanates such as 1,4-, 1,3- or 1,2-diisocyanatocyclohexane; 4,4-di(isocyanatocyclohexyl)methane; 1-isocyanato-3,3,5-trimethyl-5-(isocyanatomethyl)cyclohexane-(isophorone  
 5 diisocyanate) or 2,4- or 2,6-diisocyanato-1-methylcyclohexane. Aliphatic isocyanates generally exhibit good light fastness and UV stability, but are slower to react and produce softer polymers than the aromatic isocyanates.

Most preferably, the polyisocyanate copolymer is a blend of toluene diisocyanate (TDI) and hexamethylene diisocyanate (HDI). Such a  
 10 polyisocyanate copolymer is commercially sold under the trademark DESMODUR® HL from the Bayer Corporation, Pittsburgh, PA. DESMODUR® HL is an aliphatic/aromatic polyisocyanate copolymer based on TDI and HDI and dissolved in a n-butyl acetate. Typical properties of the DESMODUR® HL polyisocyanate copolymer are shown in Table 1 below.

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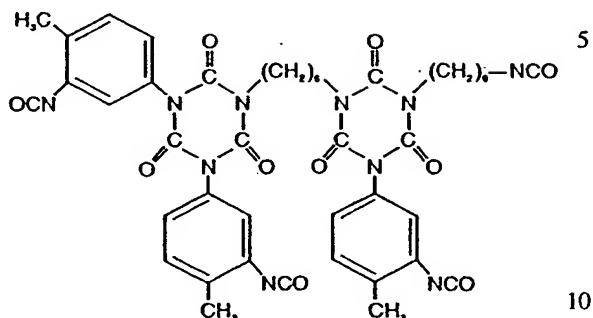
**TABLE 1**

**Typical Properties of DESMODUR® HL Polyisocyanate Copolymer**

Appearance	Clear liquid
Solids, wt. %	58-62
NCO content, %	10-11
Equivalent wt., avg. (as supplied)	400
Color, Gardner	No. 4 maximum
Viscosity @ 23°C, MPa	1,200-3,200
Specific gravity @ 20°C	1.11
Weight/gallon, lb. @ 25°C	9.4
Free monomer, % (as supplied)	0.5 maximum
Flash point (Setaflash)	87°F (31°C)



The chemical structure of the DESMODUR® HL TDI/HDI polyisocyanate copolymer is as follows.



Due to its copolymeric structure, the TDI/HDI polyisocyanate copolymer provides faster reaction times than most aliphatic polyisocyanates and many aromatic polyisocyanates. Also, the TDI/HDI polyisocyanate copolymer exhibits improved light features and UV stability over aromatic polyisocyanates. The properties of polyurethane/polyurea based upon the TDI/HDI polyisocyanate copolymer can be varied through the choice of co-reactant and degree of cross-linking. The TDI/HDI polyisocyanate copolymer is soluble in most ester, ether ester, and ketone solvents, although compatibility with aromatic hydrocarbons is limited.

It has been found that the addition of a polyisocyanate copolymer based on HDI and TDI improves the curing time while at the same time maintaining desirable qualities such as superior adhesion and abrasion resistance, and good color retention upon exposure to ultraviolet radiation. This result is unexpected because, among other things, the copolymer blend is partly aromatic, and prior urethane coatings made from aromatic diisocyanates tended to yellow very quickly upon exposure to ultraviolet light. In certain embodiments, the aromatic/aliphatic polyisocyanate copolymer includes 10-90 weight % aliphatic diisocyanate; preferably, 20-80 weight % aliphatic diisocyanate; more

preferably, 30-70 weight % aliphatic diisocyanate; and most preferably, about 50 weight % of the aliphatic diisocyanate.

The HDI/TDI polyisocyanate copolymer is mixed and reacted with at least one reactant to form a reaction mixture. The HDI/TDI polyisocyanate copolymer can be the sole isocyanate mixed and reacted with the reactant to form the reaction mixture. Alternatively, the HDI/TDI polyisocyanate copolymer and one or more isocyanates can be mixed and reacted with at least one reactant to form a reaction mixture. Preferably, the reactant is selected from the group consisting of (i) an agent having one or more hydroxyl groups, (ii) an agent having one or more amine groups, and (iii) combinations of (i) and (ii).

The isocyanate blend can be carried in a solvent. Examples of suitable solvents for the blend include methyl isobutyl ketone, methyl amyl ketone, butyl acetate and propylene glycol monomethyl ether acetate. The use of methyl isobutyl ketone as the solvent or part-solvent is advantageous because it tends to alleviate any potential moisture problems encountered with the acetate solvents.

Chain extenders may also be used with polyisocyanates to form polyurethane/polyurea. Chain extenders lengthen the main chain of polyurethane/polyurea causing end-to-end attachments. Examples of chain extenders for use in forming polyurethane/polyurea include glycol chain extenders and amine chain extenders. Suitable glycol chain extenders include, but are not limited to, ethylene glycol; propylene glycol; butane glycol; pentane glycol; hexane glycol; benzene glycol; xylene glycol; 1,4-butane diol; 1,3-butane diol; 2,3-dimethyl-2,3-butane diol; and dipropylene glycol. Suitable amine chain extenders include, but are not limited to, tetramethyl-ethylenediamine; dimethylbenzylamine; diethylbenzylamine; pentamethyldiethylenetriamine; dimethyl cyclohexylamine; tetramethyl-1,3-butanediamine; 1,2-dimethylimidazole; 2-methylimidazole; pentamethyldipropylenetriamine; and bis-(dimethylaminoethylether).

Numerous ways are known to induce cross-linking in a polymer by free radical initiation, including peroxide initiation and irradiation. The golf ball

covers or components of the present invention may be cross-linked by irradiation, preferably by light rays such as gamma or UV irradiation. Furthermore, other forms of particle irradiation, including electron beam, also can be used. Gamma radiation is preferred as golf balls or game balls can be irradiated in bulk. Gamma radiation penetrates relatively deep into the material undergoing irradiation, but also increases cross-linking of the inner core. Accordingly, the compression of the core has to be adjusted to allow for the increase in hardness stemming from the cross-linking.

Electron beam techniques are faster but cannot be used for treating in bulk as the electron beam does not sufficiently penetrate into the material and the product typically needs to be rotated to obtain an even or uniform cross-link density.

The type of irradiation to be used will depend in part upon the underlying layers. For example, certain types of irradiation may degrade windings in a wound golf ball. On the other hand, balls with a solid core would not be subject to the same concerns. However, with any type of core, certain types of irradiation will tend to cross-link and thus harden the core. Depending upon whether this type of effect is sought or is to be avoided, the appropriate type of irradiation can be selected.

The level of radiation employed depends upon the desired end characteristics of the final golf ball component. However, generally a wide range of dosage levels may be used. For example, total dosages of up to about 12.5 or even 15 Mrads may be employed. Preferably, radiation delivery levels are controlled so that the game ball is not heated above about 80°C (176°C) while being cross-linked.

Polyurethane compositions of the present invention are especially desirable as materials in forming golf balls. Polyurethanes according to the invention are suitable materials for any of a core layer, a mantle layer, and a cover layer. Most preferably, the polyurethane materials are used to form a cover layer. Golf balls according to the present invention may be formed as one-piece, two-piece, or multi-layer balls having either a wound core or a solid, non-

wound core. In a preferred form, golf balls utilizing a polyurethane composition described herein are solid, i.e., non-wound, multi-layer golf balls comprising a solid non-wound core, a cover formed from polyurethane, and one or more intermediate layers disposed between the cover and the core.

5                Since the functionality of the hydroxyl- or amine-containing reactant or the isocyanate can be varied, a wide variety of branched or cross-linked polymers can be formed. Hydroxyl-containing components cover a wide range of molecular weights and types, including polyester and polyether polyols. The polyfunctional isocyanates are preferably copolymers of TDI and HDI and can be  
10        used directly as produced or as modified. This flexibility in the selection of reactants leads to the wide range of physical properties that allows polyurethanes/polyureas to play an important role in the manufacture of one or more golf ball layers.

              The polyisocyanate copolymer reacts with a reactant in order to  
15        form a reaction product such as polyurethane/polyurea. One particular reactant that can react with the polyisocyanate copolymer is a polyol. In this regard, a polyol is typically a polyfunctional alcohol. The polyol can be an alcohol, diol, triol, etc., depending on the number of hydroxyl groups. Also, a blend of polyols and polyamines for reaction with an isocyanate is referred to as a polyol or polyol  
20        blend. Although the reaction of an amine with an isocyanate yields a polyurea linkage, the polymer produced from a mixed polyol-polyamine blend may be referred to as a polyurethane.

              The fast-chemical-produced-component can be a hydroxyl functional polyol having a hydroxyl equivalent weight in the range of 50 to 1500,  
25        with the preferred equivalent weight being 200 to 500. Compounds containing the hydroxyl functional polyol contemplated herein include polyesters, polyethers, or acrylics. Alternately, the hydroxyl functional polyol is ethylenically saturated. Suitable saturated polyesters for use herein include poly (oxydiethylene adipates) that are condensation products of diethylene glycol and  
30        adipic acid, branched with trimethylolpropane or pentaerythritol, and polycaprolactone (hydroxycaproic acid) polyesters. Suitable saturated polyethers

include polymers of propylene oxide or propylene oxide/ethylene oxide. Such materials are usually triols or diols with molecular weights between 1000 and 7000. Suitable saturated acrylics include derivatives of acrylic acid, such as methyl methacrylate, co-polymerized with hydroxyl functional monomers, such as 2-hydroxy-ethyl methacrylate. Polyols marketed by the Bayer Corporation, Pittsburgh, PA, under the trademark DESMOPHEN® are particularly contemplated for use herein. One such polyol is DESMOPHEN® 651A-65. Several others are DESMOPHEN® 670A-80 and DESMOPHEN® 631A-75.

In addition to these polyhydroxyl compounds, other materials containing a reactive hydrogen atom that would react with the isocyanate copolymer to form the polyurethane/polyurea can be utilized. Such materials include polyamines, polyamides, short oil alkyds, castor oil, epoxy resins with secondary hydroxyl groups, phenolic resins, and hydroxyl functional vinyl resins. Suitable examples of such materials include ANCAMINE™ 2071, a modified polyamine marketed by Pacific Anchor Chemical Corporation, Los Angeles, CA; EPON® V-40, a polyamide marketed by Shell Oil Company, Houston, TX; AROPLAZ® 1133-X-69, a short oil alkyd by Reichhold Inc., Minneapolis, MN; EPON® resin 828, an epoxy resin marketed by Shell Oil Company; PENTALYN® 802A, a phenolic modified polyester resin marketed by Hercules Inc., Wilmington, DE; and VAGH™, a hydroxyl functional vinyl resin marketed by Union Carbide, Danbury, CT.

The preferred method of forming a fast-chemical-reaction-produced component for a golf ball according to the invention is by reaction injection molding (RIM). RIM is a process by which highly reactive liquids are injected into a closed mold, mixed usually by impingement and/or mechanical mixing in an in-line device such as a "peanut mixer", where they polymerize primarily in the mold to form a coherent, one-piece molded article. The RIM processes usually involve a rapid reaction between one or more reactive components such as a polyether or polyester polyol, polyamine, or other material with an active hydrogen, and one or more isocyanate-containing constituents, often in the presence of a catalyst. The constituents are stored in separate tanks prior to

molding and may be first mixed in a mix head upstream of a mold and then injected into the mold. The liquid streams are metered in the desired weight to weight ratio and fed into an impingement mix head, with mixing occurring under high pressure, e.g., 1500 to 3000 psi. The liquid streams impinge upon each other in the mixing chamber of the mix head and the mixture is injected into the mold. One of the liquid streams typically contains a catalyst for the reaction. The constituents react rapidly after mixing to gel and form polyurethane polymers. Polyureas, epoxies, and various unsaturated polyesters also can be molded by RIM.

10           The RIM process used in forming components of a multi-layered golf ball disclosed herein is substantially different from, and advantageous over, the conventional injection and compression molding techniques.

          First, during the RIM process of the present application, the chemical reaction, i.e., the mixture of isocyanate from the isocyanate tank and polyol from the polyol tank, occurs during the molding process. Specifically, the mixing of the reactants occurs in the recirculation mix head and the after mixer, both of which are connected directly to the injection mold. The reactants are simultaneously mixed and injected into the mold, forming the desired component.

20           Typically, prior art techniques utilize mixing of reactants to occur before the molding process. Mixing under either compression or injection molding occurs in a mixer that is not connected to the molding apparatus. Thus, the reactants must first be mixed in a mixer separate from the molding apparatus, then added into the apparatus. Such a process causes the mixed reactants to first solidify, then later melt in order to properly mold.

          Second, the RIM process requires lower temperatures and pressures during molding than does injection or compression molding. Under the RIM process, the molding temperature is maintained at about 100-120°F in order to ensure proper injection viscosity. Compression molding is typically completed at a higher molding temperature of about 320°F (160°C). Injection molding is completed at even a higher temperature range of 392-482°F (200-

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250°C). At this elevated temperature, the viscosity of the molten resin usually is in the range of 50,000 to about 1,000,000 centipoise, and is typically around 200,000 centipoise. In an injection molding process, the solidification of the resins occurs after about 10 to about 90 seconds, depending upon the size of the molded product, the temperature and heat transfer conditions, and the hardness of the injection molded material. Molding at a lower temperature is beneficial when, for example, the cover is molded over a very soft core so that the very soft core does not melt or decompose during the molding process.

Third, the RIM process creates more favorable durability properties in a golf ball than does conventional injection or compression molding. The preferred process of the present invention provides improved durability for a golf ball cover by providing a uniform or "seamless" cover in which the properties of the cover material in the region along the parting line are generally the same as the properties of the cover material at other locations on the cover, including at the poles. The improvement in durability is due to the fact that the reaction mixture is distributed uniformly into a closed mold. This uniform distribution of the injected materials reduces or eliminates knit-lines and other molding deficiencies which can be caused by temperature difference and/or reaction difference in the injected materials. The RIM process of the present invention results in generally uniform molecular structure, density and stress distribution as compared to conventional injection molding processes, where failure along the parting line or seam of the mold can occur because the interfacial region is intrinsically different from the remainder of the cover layer and, thus, can be weaker or more stressed.

Fourth, the RIM process is relatively faster than the conventional injection and compression molding techniques. In the RIM process, the chemical reaction takes place in under 5 minutes, typically in less than two minutes, preferably in under one minute and, in many cases, in about 30 seconds or less. The demolding time of the present application is 10 minutes or less. The molding process alone for the conventional methods typically take

about 15 minutes. Thus, the overall speed of the RIM process makes it advantageous over the injection and compression molding methods.

The fast-chemical-reaction-produced component has a flex modulus of 1 to 310 kpsi, more preferably 5 to 100 kpsi, and most preferably 5 to 80 kpsi. The subject component can be a cover with a flex modulus which is higher than that of the centermost component of the cores, as in a liquid center core and some solid center cores. Furthermore, the fast-chemical-reaction-produced component can be a cover with a flex modulus that is higher than that of the immediately underlying layer, as in the case of a wound core. The core can be one piece or multi-layer, each layer can be either foamed or unfoamed, and density adjusting fillers, including metals, can be used. The cover of the ball can be harder or softer than any particular core layer.

The fast-chemical-reaction-produced component can incorporate suitable additives and/or fillers. When the component is an outer cover layer, pigments or dyes, accelerators and U.V. stabilizers can be added. An example of a suitable white pigment is titanium dioxide. Examples of suitable U.V. light stabilizers are provided in commonly assigned U.S. Patent No. 5,494,291, herein incorporated by reference. Fillers which can be incorporated into the fast-chemical-reaction-produced cover or core component include those listed herein. Furthermore, compatible polymeric materials can be added. For example, when the component comprises polyurethane and/or polyurea, such polymeric materials include polyurethane ionomers, polyamides, etc.

A golf ball core layer formed from a fast-chemical-reaction-produced material according to the present invention typically contains 0 to 20 weight percent of such filler material, and more preferably 1 to 15 weight percent. When the fast-chemical-reaction-produced component is a core, the additives typically are selected to control the density, hardness and/or COR.

A golf ball inner cover layer or mantle layer formed from a fast-chemical-reaction-produced material according to the present invention typically contains 0 to 60 weight percent of filler material, more preferably 1 to 30 weight percent, and most preferably 1 to 20 weight percent.



A golf ball outer cover layer formed from a fast-chemical-reaction-produced material according to the present invention typically contains 0 to 20 weight percent of filler material, more preferably 1 to 10 weight percent, and most preferably 1 to 5 weight percent.

5           The reaction mixture viscosity should be sufficiently low to ensure that the empty space in the mold is completely filled. The reactant materials generally are preheated to 90 to 150°F before they are mixed. In most cases it is necessary to preheat the mold to, e.g., 100 to 180°F, to ensure proper injection viscosity.

10           As indicated above, one or more cover layers of a golf ball can be formed from a fast-chemical-reaction-produced material according to the present invention.

Referring now to the drawings, and first to FIG. 1, a golf ball having a cover comprising a RIM polyurethane is shown. The golf ball 10 includes a polybutadiene core 12 and a polyurethane cover 14 formed by RIM.

15           Referring now to FIG. 2, a golf ball having a core comprising a RIM polyurethane is shown. The golf ball 20 has a RIM polyurethane core 22, and a RIM polyurethane cover 24.

Referring to FIG. 3, a multi-layer golf ball 30 is shown with a solid core 32 containing recycled RIM polyurethane, a mantle cover layer 34 comprising RIM polyurethane, and an outer cover layer 36. The outer cover layer 36 can comprise RIM polyurethane. Alternatively, the outer cover layer 36 can comprise ionomer or another conventional golf ball cover material. Such conventional golf ball cover materials typically contain titanium dioxide utilized to make the cover white in appearance. Non-limiting examples of multi-layer golf balls according to the invention with two cover layers include those with RIM polyurethane mantles having a thickness of from about 0.01 to about 0.20 inches and a Shore D hardness of 10 to 95, covered with ionomeric or non-ionomeric thermoplastic, balata or other covers having a Shore D hardness of from about 10 to about 95 and a thickness of 0.020 to 0.20 inches.

Referring next to FIG. 4, a process flow diagram for forming a RIM cover of polyurethane is shown. Isocyanate from bulk storage is fed through line 80 to an isocyanate tank 100. Preferably, the isocyanate is an isocyanate copolymer of TDI and HDI such as the one marketed under the trademark  
5 DESMODUR® HL by Bayer Corp., Pittsburgh, PA. The isocyanate is heated to the desired temperature, e.g. 90 to about 150°F, by circulating it through heat exchanger 82 via lines 84 and 86. Polyol, polyamine, or another compound with an active hydrogen atom is conveyed from bulk storage to a polyol tank 108 via line 88. The polyol is heated to the desired temperature, e.g. 90 to about 150°F,  
10 by circulating it through heat exchanger 90 via lines 92 and 94. Dry nitrogen gas is fed from nitrogen tank 96 to isocyanate tank 100 via line 97 and to polyol tank 108 via line 98. Isocyanate is fed from isocyanate tank 100 via line 102 through a metering cylinder or metering pump 104 into recirculation mix head inlet line 106. Polyol is fed from polyol tank 108 via line 110 through a metering cylinder  
15 or metering pump 112 into a recirculation mix head inlet line 114. The recirculation mix head 116 receives isocyanate and polyol, mixes them, and provides for them to be fed through nozzle 118 into injection mold 120. The injection mold 120 has a top mold 122 and a bottom mold 124. Mold heating or cooling can be performed through lines 126 in the top mold 122 and lines 140 in  
20 the bottom mold 124. The materials are kept under controlled temperature conditions to insure that the desired reaction profile is maintained.

The polyol component typically contains additives, such as stabilizers, flow modifiers, catalysts, combustion modifiers, blowing agents, fillers, pigments, optical brighteners, and release agents to modify physical  
25 characteristics of the cover. Recycled polyurethane/polyurea also can be added to the core. Polyurethane/polyurea constituent molecules that were derived from recycled polyurethane can be added in the polyol component.

Inside the mix head 116, injector nozzles impinge the isocyanate and polyol at ultra-high velocity to provide excellent mixing. Additional mixing  
30 preferably is conducted using an aftermixer 130, which typically is constructed inside the mold between the mix head and the mold cavity.

As is shown in FIG. 5, the mold includes a golf ball cavity chamber 134 in which a spherical golf ball cavity 132 with a dimpled, inner spherical surface 136 is defined. The aftermixer 130 can be a peanut aftermixer, as is shown in Fig 5, or in some cases another suitable type, such as a heart, harp or dipper. However, the aftermixer does not have to be incorporated into the mold design. An overflow channel 138 receives overflow material from the golf ball cavity 132 through a shallow vent 142. Heating/cooling passages 126 and 140, which preferably are in a parallel flow arrangement, carry heat transfer fluids such as water, oil, etc. through the top mold 122 and the bottom mold 124.

The mold cavity contains retractable pins and is generally constructed in the same manner as a mold cavity used to injection mold a thermoplastic, e.g., ionomeric golf ball cover. However, two differences when RIM is used are that tighter pin tolerances generally are required, and a lower injection pressure is used. Also, because of the lower injection pressure, the molds can be produced from lower strength material such as aluminum.

The golf balls formed according to the present invention can be coated using a conventional two-component spray coating or can be coated during the RIM process, i.e., using an in-mold coating process.

One of the significant advantages of the RIM process according to the invention is that polyurethane or other cover materials can be recycled and used in golf ball cores. Recycling can be conducted by, for example, glycolysis. Typically, 10 to 90% of the material which is injection molded actually becomes part of the cover. The remaining 10 to 90% is recycled.

Recycling of polyurethanes by glycolysis is known from, for example, RIM Part and Mold Design - Polyurethanes, 1995, Bayer Corp., Pittsburgh, PA. Another significant advantage of the present invention is that because reaction injection molding occurs at low temperatures and pressures, i.e., 90 to 180°F and 50 to 200 psi, this process is particularly beneficial when a cover is to be molded over a very soft core. When higher pressures are used for molding over soft cores, the cores "shut off" i.e., deform and impede the flow of material causing uneven distribution of cover material.

An additional polyurethane component which can be used in the present invention incorporates TMXDI (META) aliphatic isocyanate (Cytec Industries, West Paterson, NJ). Polyurethanes based on meta-tetramethylxylylene diisocyanate can provide improved gloss retention, U.V. light stability, thermal stability and hydrolytic stability. Additionally, TMXDI (META) aliphatic isocyanate has demonstrated favorable toxicological properties. Furthermore, because it has a low viscosity, it is usable with a wider range of diols (to polyurethane) and diamines (to polyureas). If TMXDI is used, it typically, but not necessarily, is added as a direct replacement for some or all of the other aliphatic isocyanates in accordance with the suggestions of the supplier. Because of slow reactivity of TMXDI, it may be useful or necessary to use catalysts to have practical demolding times. Hardness, tensile strength and elongation can be adjusted by adding further materials in accordance with the supplier's instructions.

Golf ball cores also can be made using the materials and processes of the invention. To make a golf ball core using RIM polyurethane, the same processing conditions are used as are described above with respect to covers. One difference is, of course, that no retractor pins are needed in the mold. Furthermore, an undimpled, smaller mold is used. If, however, a one piece ball is desired, a dimpled mold would be used.

Golf balls typically have indicia and/or logos stamped or formed thereon. Such indicia can be applied by printing using a material or a source of energetic particles after the ball core and/or cover have been reaction-injection-molded according to the present invention. Printed indicia can be formed from materials known in the art, such as ink, foil (for use in foil transfer), etc. Indicia printed using a source of energetic particles or radiation can be applied by burning with a laser, burning with heat, directed electrons, or light, phototransformations of, e.g., U.V. ink, impingement by particles, impingement by electromagnetic radiation, etc. Furthermore, the indicia can be applied in the same manner as an in-mold coating, i.e., by applying the indicia to the surface of the mold prior to molding of the cover.

The polyurethane which is selected for use as a golf ball cover preferably has a Shore D hardness of 10 to 95, more preferably 30 to 75 Shore D (Shore C hardness of about 45 to greater than 100), and most preferably 30 to 50 (Shore C hardness of 45 to 75) for a soft cover layer and 50 to 75 (Shore C hardness of at least about 75 or more) for a hard cover layer. The polyurethane which is to be used for a cover layer preferably has a flex modulus of 1 to 310 kpsi, more preferably 5 to 100 kpsi, and most preferably 5 to 20 kpsi for a soft cover layer and 30 to 70 kpsi for a hard cover layer.

Non-limiting examples of other suitable RIM systems for use in the present invention are BAYFLEX<sup>®</sup> elastomeric polyurethane RIM systems, BAYDUR<sup>®</sup> GS solid polyurethane RIM systems, PRISM<sup>®</sup> solid polyurethane RIM systems, all from Bayer Corp. (Pittsburgh, PA), SPECTRIM<sup>®</sup> reaction moldable polyurethane and polyurea systems from Dow Chemical USA (Midland, MI), including SPECTRIM<sup>®</sup> MM 373-A (isocyanate) and 373-B (polyol), and ELASTOLIT<sup>®</sup> SR systems from BASF (Parsippany, NJ). Preferred RIM systems include BAYFLEX<sup>®</sup> MP-10000 and BAYFLEX<sup>®</sup> 110-50, filled and unfilled. Further preferred examples are polyols, polyamines and isocyanates formed by processes for recycling polyurethanes and polyureas. Preferably, these systems are utilized with a copolymer of TDI and HDI such as DESMODUR<sup>®</sup> HL.

A wide array of materials may be used for the cores and mantle layer(s) of the present invention golf balls. For instance, the core and mantle or interior layer materials disclosed in U.S. Patent Nos. 5,833,553; 5,830,087; 5,820,489; and 5,820,488, all of which are hereby incorporated by reference, may be employed. In particular, it is preferred to utilize the cores described in U.S. Patent Application Serial Nos. 09/226,340 filed January 6, 1999; and 09/226,727 filed January 7, 1999, both of which are hereby incorporated by reference.

A variety of conventional materials may be used for one or more cover layers. The cover layer(s) may employ materials disclosed in U.S. Patent Nos. 6,309,314; 6,277,921; 6,220,972; 6,150,470; 6,126,559; 6,117,025;

5,902,855; 5,895,105; 5,688,869; 5,591,803; and 5,542,677; hereby incorporated by reference.

In a particularly preferred form of the invention, at least one layer of the golf ball contains at least one part by weight of a filler. Fillers preferably are used to adjust the density, flex modulus, mold release, and/or melt flow index of a layer. More preferably, at least when the filler is for adjustment of density or flex modulus of a layer, it is present in an amount of at least 5 parts by weight based upon 100 parts by weight of the layer composition. With some fillers, up to about 200 parts by weight can be used.

A density adjusting filler according to the invention preferably is a filler which has a specific gravity which is at least 0.05 and more preferably at least 0.1 higher or lower than the specific gravity of the layer composition. Particularly preferred density adjusting fillers have specific gravities which are higher or lower than the specific gravity of the resin composition by 0.2 or more, and even more preferably by 2.0 or more.

A flex modulus adjusting filler according to the invention is a filler which, e.g. when used in an amount of 1 to 100 parts by weight based upon 100 parts by weight of resin composition, will raise or lower the flex modulus (ASTM® D-790) of the resin composition by at least 1% and preferably at least 5% as compared to the flex modulus of the resin composition without the inclusion of the flex modulus adjusting filler.

A mold release adjusting filler is a filler which allows for the easier removal of a part from a mold, and eliminates or reduces the need for external release agents which otherwise could be applied to the mold. A mold release adjusting filler typically is used in an amount of up to about 2 weight percent based upon the total weight of the layer.

A melt flow index adjusting filler is a filler which increases or decreases the melt flow, or ease of processing, of the composition.

The layers may contain coupling agents that increase adhesion of materials within a particular layer, e.g. to couple a filler to a resin composition, or between adjacent layers. Non-limiting examples of coupling agents include

titanates, zirconates and silanes. Coupling agents typically are used in amounts of 0.1 to 2 weight percent based upon the total weight of the composition in which the coupling agent is included.

A density adjusting filler is used to control the moment of inertia, and thus the initial spin rate of the ball and spin decay. The addition in one or more layers, and particularly in the outer cover layer, of a filler with a lower specific gravity than the resin composition results in a decrease in moment of inertia and a higher initial spin rate than would result if no filler were used. The addition in one or more of the cover layers, and particularly in the outer cover layer, of a filler with a higher specific gravity than the resin composition, results in an increase in moment of inertia and a lower initial spin rate. High specific gravity fillers are preferred as less volume is used to achieve the desired inner or outer cover total weight. Nonreinforcing fillers are also preferred as they have minimal effect on COR. Preferably, the filler does not chemically react with the resin composition to a substantial degree, although some reaction may occur when, for example, zinc oxide is used in a shell layer which contains some ionomer.

The density-increasing fillers for use in the invention preferably have a specific gravity in the range of 1.0 to 20. The density-reducing fillers for use in the invention preferably have a specific gravity of 0.06 to 1.4, and more preferably 0.06 to 0.90. The flex modulus increasing fillers have a reinforcing or stiffening effect due to their morphology, their interaction with the resin, or their inherent physical properties. The flex modulus reducing fillers have an opposite effect due to their relatively flexible properties compared to the matrix resin. The melt flow index increasing fillers have a flow enhancing effect due to their relatively high melt flow versus the matrix. The melt flow index decreasing fillers have an opposite effect due to their relatively low melt flow index versus the matrix.

Fillers which may be employed in layers other than the outer cover layer may be or are typically in a finely divided form, for example, in a size generally less than about 20 mesh, preferably less than about 100 mesh U.S.

standard size, except for fibers and flock, which are generally elongated. Flock and fiber sizes should be small enough to facilitate processing. Filler particle size will depend upon desired effect, cost, ease of addition, and dusting considerations. The filler preferably is selected from the group consisting of

5 precipitated hydrated silica, clay, talc, asbestos, glass fibers, aramid fibers, mica, calcium metasilicate, barium sulfate, zinc sulfide, lithopone, silicates, silicon carbide, diatomaceous earth, polyvinyl chloride, carbonates, metals, metal alloys, tungsten carbide, metal oxides, metal stearates, particulate carbonaceous materials, micro balloons, and combinations thereof. Non-limiting examples of

10 suitable fillers, their densities, and their preferred uses are set forth in Table 2 as follows:

**TABLE 2**  
**Filler Table**

Filler Type	Spec. Grav.	Comments
Precipitated hydrated silica	2	1,2
Clay	2.62	1,2
Talc	2.85	1,2
Asbestos	2.5	1,2
Glass fibers	2.55	1,2
Aramid fibers (KEVLAR®)	1.44	1,2
Mica	2.8	1,2
Calcium metasilicate	2.9	1,2
Barium sulfate	4.6	1,2
Zinc sulfide	4.1	1,2
Lithopone	4.2 - 4.3	1,2
Silicates	2.1	1,2
Silicon carbide platelets	3.18	1,2
Silicon carbide whiskers	3.2	1,2
Tungsten carbide	15.6	1
Diatomaceous earth	2.3	1,2
Polyvinyl chloride	1.41	1,2



<b>Carbonates</b>		
Calcium carbonate	2.71	1,2
Magnesium carbonate	2.2	1,2
<b>Metals and Alloys (powders)</b>		
Titanium	4.51	1
Tungsten	19.35	1
Aluminum	2.7	1
Bismuth	9.78	1
Nickel	8.9	1
Molybdenum	10.2	1
Iron	7.86	1
Steel	7.8 - 7.9	1
Lead	11.4	1,2
Copper	8.94	1
Brass	8.2 - 8.4	1
Boron	2.34	1
Boron carbide whiskers	2.52	1,2
Bronze	8.70 - 8.74	1
Cobalt	8.92	1
Beryllium	1.84	1
Zinc	7.14	1
Tin	7.31	1
<b>Metal Oxides</b>		
Zinc oxide	5.57	1,2
Iron oxide	5.1	1,2
Aluminum oxide	4	
Titanium oxide	3.9 - 4.1	1,2
Magnesium oxide	3.3 - 3.5	1,2
Zirconium oxide	5.73	1,2
<b>Metal Stearates</b>		
Zinc stearate	1.09	3,4
Calcium stearate	1.03	3,4

Barium stearate	1.23	3,4
Lithium stearate	1.01	3,4
Magnesium stearate	1.03	3,4
<b>Particulate carbonaceous materials</b>		
Graphite	1.5 - 1.8	1,2
Carbon black	1.8	1,2
Natural bitumen	1.2 - 1.4	1,2
Cotton flock	1.3 - 1.5	1,2
Leather fiber	1.2 - 1.4	1,2
<b>Micro balloons</b>		
Glass	0.15 - 1.1	1,2
Ceramic	0.2 - 0.7	1,2
Fly ash	0.6 - 0.8	1,2
<b>Coupling Agents Adhesion Promoters</b>		
Titanates	0.95 - 1.17	
Zirconates	0.92 - 1.11	
Silane	0.95 - 1.2	

**COMMENTS:**

- 5
- 1 Particularly useful for adjusting density of the cover layer.
- 2 Particularly useful for adjusting flex modulus of the cover layer.
- 3 Particularly useful for adjusting mold release of the cover layer.
- 10 4 Particularly useful for increasing melt flow index of the cover layer.
- All fillers except for metal stearates would be expected to reduce the melt flow index of an injection molded cover layer.
- 15 The amount of filler employed is primarily a function of weight requirements and distribution

The following examples are included for purposes of illustration

20 and are not intended to be limiting. The examples were tested with the definitions set forth below, unless otherwise indicated.

### Scuff Resistance

The scuff resistance test is conducted in the following manner. A TOP-FLITE® tour pitching wedge (1994) with box grooves is obtained and is mounted in a MIYAMAE® driving machine. The club face is oriented for a square hit. The forward/backward tee position is adjusted so that the tee is 4 inches behind the point in the downswing where the club was vertical. The height of the tee and the toe-heel position of the club relative to the tee are adjusted in order that the center of the impact mark is about 3/4 of an inch above the sole and is centered to the heel across the face. The machine is operated at a club head speed of 125 feet per second. A minimum of 3 samples of each ball are tested. Each ball is hit 3 times. After testing, the balls are rated according to the following scale:

Rating	Type of Damage
1	Little or no damage (groove markings or dents)
2	Small cuts and/or ripples in cover
3	Moderate amount of material lifted from ball surface, but still attached to ball
4	Material removed or barely attached

The tested balls are primed and top coated.

### Cut Resistance

Cut resistance is measured in accordance with the following procedure. A golf ball is fired at 135 feet per second against the leading edge of a 1994 TOP-FLITE® Tour pitching wedge, wherein the leading edge radius is 1/32 inch, the loft angle is 51 degrees, the sole radius is 2.5 inches, and the bounce angle is 7 degrees.

The cut resistance of the balls tested herein is evaluated on a scale of 1 - 5. A 5 represents a cut that extends completely through the cover to the core; a 4 represents a cut that does not extend completely through the cover but

that does break the surface; a 3 does not break the surface of the cover but does leave a permanent dent; a 2 leaves only a slight crease which is permanent but not as severe as 3; and a 1 represents virtually no visible indentation or damage of any sort.

5

### Durability

Durability is determined by firing a golf ball at 135 ft/sec (at 72°F) into a steel pentagonal container, the walls of which are steel plates. The container 210, which is shown schematically in FIG. 6, has a 19 ½ inch long insert plate 212 mounted therein, the central portion 214 of which has horizontally extending square grooves on it which are intended to simulate a square grooved face of a golf club. The grooves, which are shown in an exaggerated form in FIG. 7, have a width 230 of 0.033 inches, a depth 232 of 0.100 inches, and are spaced apart from one another by land areas 234 having a width of 0.130 inches. The five walls 216 of the pentagonal container each have a length of 14 ½ inches. The inlet wall is vertical and the insert plate is mounted such that it inclines upward 30° relative to a horizontal plane away from opening 220 in container 210. The ball travels 15 ½ to 15 ¾ inches horizontally from its point of entry into the container 210 until it hits the square-grooved central portion 214 of insert plate 212. The angle between the line of trajectory of the ball and the insert plate 212 is 30°. The balls are subjected to 70 or more blows (firings) and are inspected at regular intervals for breakage (i.e., any signs of cover cracking or delamination). If a microcrack forms in a ball, its speed will change and the operator is alerted. The operator then visually inspects the ball. If the microcrack cannot yet be observed, the ball is returned to the test until a crack can be visually detected.

A ball is assigned a Durability Rating according to the following scale. A sample of twelve balls of the same type are obtained and are tested using the durability test apparatus previously described. If less than all of the balls in the sample survive 70 blows each without cracking, the ball is assigned a Durability Rating of 1. If all of the balls survive 70 blows and one or two of the

twelve balls crack before 100 blows, the ball is assigned a Durability Rating of 2. If all twelve balls in the sample survive 100 blows each, but seven or more balls crack at less than 200 blows each, the ball is assigned a Durability Rating of 3. If all twelve balls in the sample survive 100 blows and at least six out of the  
5 twelve balls in the sample also survive 200 blows, the ball is assigned a Durability Rating of 4.

#### **Shore D or C Hardness**

As used herein, "Shore D hardness" or "Shore C hardness" of a  
10 cover is measured generally in accordance with ASTM® D-2240, except the measurements are made on the curved surface of the molded outer cover, rather than on a plaque. Furthermore, the Shore hardness of the cover is measured while the cover remains over the core. When a hardness measurement is made on a dimpled cover, Shore hardness is measured at a land area of the dimpled  
15 cover.

#### **Coefficient of Restitution**

The resilience or coefficient of restitution (COR) of a golf ball is the constant "e," which is the ratio of the relative velocity of an elastic sphere after  
20 direct impact to that before impact. As a result, the COR ("e") can vary from 0 to 1, with 1 being equivalent to a perfectly or completely elastic collision and 0 being equivalent to a perfectly or completely inelastic collision.

COR, along with additional factors such as club head speed, club head mass, ball weight, ball size and density, spin rate, angle of trajectory and  
25 surface configuration (i.e., dimple pattern and area of dimple coverage) as well as environmental conditions (e.g. temperature, moisture, atmospheric pressure, wind, etc.) generally determine the distance a ball will travel when hit. Along this line, the distance a golf ball will travel under controlled environmental conditions is a function of the speed and mass of the club and size, density and resilience  
30 (COR) of the ball and other factors. The initial velocity of the club, the mass of the club and the angle of the ball's departure are essentially provided by the

golfer upon striking. Since club head, club head mass, the angle of trajectory and environmental conditions are not determinants controllable by golf ball producers, and the ball size and weight are set by the United States Golf Association (U.S.G.A.), these are not factors of concern among golf ball manufacturers. The factors or determinants of interest with respect to improved distance are generally the coefficient of restitution (COR) and the surface configuration (dimple pattern, ratio of land area to dimple area, etc.) of the ball.

The COR in solid core balls is a function of the composition of the molded core and of the cover. The molded core and/or cover may be comprised of one or more layers such as in multi-layered balls. In balls containing a wound core (i.e., balls comprising a liquid or solid center, elastic windings, and a cover), the coefficient of restitution is a function of not only the composition of the center and cover, but also the composition and tension of the elastomeric windings. As in the solid core balls, the center and cover of a wound core ball may also consist of one or more layers.

The coefficient of restitution is the ratio of the outgoing velocity to the incoming velocity. The coefficient of restitution of a golf ball is measured by propelling a ball horizontally at a speed of 125 +/- 5 feet per second (fps) and corrected to 125 fps against a generally vertical, hard, flat steel plate and measuring the ball's incoming and outgoing velocities electronically. Speeds are measured with a pair of Oehler Mark 55 ballistic screens available from Oehler Research, Inc., P.O. Box 9135, Austin, TX 78766, which provide a timing pulse when an object passes through them. The screens are separated by 36 inches and are located 25.25 inches and 61.25 inches from the rebound wall. The ball speed is measured by timing the pulses from screen 1 to screen 2 on the way into the rebound wall (as the average speed of the ball over 36 inches), and then the exit speed is timed from screen 2 to screen 1 over the same distance. The rebound wall is tilted 2 degrees from a vertical plane to allow the ball to rebound slightly downward in order to miss the edge of the cannon that fired it. The rebound wall is solid steel 2.0 inches thick.

As indicated above, the incoming speed should be 125  $\pm$ 5 fps but corrected to 125 fps. The correlation between COR and forward or incoming speed has been studied and a correction has been made over the  $\pm$ 5 fps range so that the COR is reported as if the ball had an incoming speed of exactly 125.0  
5 fps.

The coefficient of restitution must be carefully controlled in all commercial golf balls if the ball is to be within the specifications regulated by the U.S.G.A. As mentioned to some degree above, the U.S.G.A. standards indicate that a "regulation" ball cannot have an initial velocity exceeding 255 feet per  
10 second in an atmosphere of 75 °F when tested on a U.S.G.A. machine. Since the coefficient of restitution of a ball is related to the ball's initial velocity, it is highly desirable to produce a ball having sufficiently high coefficient of restitution to closely approach the U.S.G.A. limit on initial velocity, while having an ample degree of softness (i.e., hardness) to produce enhanced playability (i.e., spin,  
15 etc.).

### Compression

PGA compression is another important property involved in the performance of a golf ball. The compression of the ball can affect the playability  
20 of the ball on striking and the sound or "click" produced. Similarly, compression can affect the "feel" of the ball (i.e., hard or soft responsive feel), particularly in chipping and putting.

Moreover, while compression itself has little bearing on the distance performance of a ball, compression can affect the playability of the ball  
25 on striking. The degree of compression of a ball against the club face and the softness of the cover strongly influence the resultant spin rate. Typically, a softer cover will produce a higher spin rate than a harder cover. Additionally, a harder core will produce a higher spin rate than a softer core. This is because at impact a hard core serves to compress the cover of the ball against the face of the club  
30 to a much greater degree than a soft core thereby resulting in more "grab" of the ball on the clubface and subsequent higher spin rates. In effect the cover is

squeezed between the relatively incompressible core and clubhead. When a softer core is used, the cover is under much less compressive stress than when a harder core is used and therefore does not contact the clubface as intimately. This results in lower spin rates.

5           The term "compression" utilized in the golf ball trade generally defines the overall deflection that a golf ball undergoes when subjected to a compressive load. For example, PGA compression indicates the amount of change in a golf ball's shape upon striking. The development of solid core technology in two-piece balls has allowed for much more precise control of  
10   compression in comparison to thread wound three-piece balls. This is because in the manufacture of solid core balls, the amount of deflection or deformation is precisely controlled by the chemical formula used in making the cores. This differs from wound three-piece balls wherein compression is controlled in part by the winding process of the elastic thread. Thus, two-piece and multilayer solid  
15   core balls exhibit much more consistent compression readings than balls having wound cores such as the thread wound three-piece balls.

          In the past, PGA compression related to a scale of from 0 to 200 given to a golf ball. The lower the PGA compression value, the softer the feel of the ball upon striking. In practice, tournament quality balls have compression  
20   ratings around 70 to 110, and preferably around 80 to 100.

          In determining PGA compression using the 0 to 200 scale, a standard force is applied to the external surface of the ball. A ball which exhibits no deflection (0.0 inches in deflection) is rated 200 and a ball which deflects 2/10th of an inch (0.2 inches) is rated 0. Every change of .001 of an inch in  
25   deflection represents a 1 point drop in compression. Consequently, a ball which deflects 0.1 inches (100 x .001 inches) has a PGA compression value of 100 (i.e., 200 to 100) and a ball which deflects 0.110 inches (110 x .001 inches) has a PGA compression of 90 (i.e., 200 to 110).

          In order to assist in the determination of compression, several  
30   devices have been employed by the industry. For example, PGA compression is determined by an apparatus fashioned in the form of a small press with an upper



and lower anvil. The upper anvil is at rest against a 200-pound die spring, and the lower anvil is movable through 0.300 inches by means of a crank mechanism. In its open position the gap between the anvils is 1.780 inches allowing a clearance of 0.100 inches for insertion of the ball. As the lower anvil is raised by the crank, it compresses the ball against the upper anvil, such compression occurring during the last 0.200 inches of stroke of the lower anvil, the ball then loading the upper anvil which in turn loads the spring. The equilibrium point of the upper anvil is measured by a dial micrometer if the anvil is deflected by the ball more than 0.100 inches (less deflection is simply regarded as zero compression) and the reading on the micrometer dial is referred to as the compression of the ball. In practice, tournament quality balls have compression ratings around 80 to 100 which means that the upper anvil was deflected a total of 0.120 to 0.100 inches.

An example to determine PGA compression can be shown by utilizing a golf ball compression tester produced by OK Automation, Sinking Spring, PA. The value obtained by this tester relates to an arbitrary value expressed by a number which may range from 0 to 100, although a value of 200 can be measured as indicated by two revolutions of the dial indicator on the apparatus. The value obtained defines the deflection that a golf ball undergoes when subjected to compressive loading.

Alternative devices have also been employed to determine compression. For example, Applicant also utilizes a modified Riehle Compression Machine originally produced by Riehle Bros. Testing Machine Company, Philadelphia, PA to evaluate compression of the various components (i.e., cores, mantle cover balls, finished balls, etc.) of the golf balls. The Riehle compression device determines deformation in thousandths of an inch under a load designed to emulate the 200 pound spring constant of the Atti or PGA compression testers. Using such a device, a Riehle compression of 61 corresponds to a deflection under load of 0.061 inches.

Additionally, an approximate relationship between Riehle compression and PGA compression exists for balls of the same size. It has

been determined by Applicant that Riehle compression corresponds to PGA compression by the general formula  $\text{PGA compression} = 160 - \text{Riehle compression}$ . Consequently, 80 Riehle compression corresponds to 80 PGA compression, 70 Riehle compression corresponds to 90 PGA compression, and 60 Riehle compression corresponds to 100 PGA compression. For reporting purposes, Applicant's compression values are usually measured as Riehle compression and converted to PGA compression.

Furthermore, additional compression devices may also be utilized to monitor golf ball compression so long as the correlation to PGA compression is known. These devices have been designed, such as a Whitney Tester, to correlate or correspond to PGA compression through a set relationship or formula.

#### **Example 1**

A polybutadiene golf ball core having a diameter of 1.545 inches, a PGA compression of about 65 and a coefficient of restitution of about 0.770 was obtained. A dimpled cover having a thickness of 0.0675 inches was reaction injection molded over the core. The cover comprised BAYFLEX® MP 10000 resin (Bayer). The resulting ball had a PGA compression of 78, a COR of 0.720 and a Shore D cover hardness of 39. The ball met standard durability tests and had an excellent scuff resistance rating of 1. It is expected that this cover also has an excellent cut resistance rating.

#### **Example 2**

A polybutadiene golf ball center having a diameter of 1.48 inches, a PGA compression of about 45, and a coefficient of restitution (COR) of about 0.788 was obtained. A 0.050 inch thick mantle layer was then injection molded over the center, made from a high acid thermoplastic ionomer material. The mantled core diameter was 1.58 inches, its PGA compression was about 75, and its COR was about 0.810. A dimpled cover having a thickness of about 0.050 inches was reaction injection molded over the mantled core. The cover was

comprised of Bayer's BAYFLEX<sup>®</sup> MP 10000 resin. The setting time of the mixed resin was about 4.5 seconds and the mold release time was about 20 seconds. The isocyanate tank temperature was about 115°F and the polyol tank temperature was about 138°F. The mold temperature was about 157°F. The resulting ball, after painting, had a pole diameter of about 1.6877 inches, an equator diameter of about 1.6880 inches, a weight of about 45.61 grams, a PGA compression of about 80, a COR of about 0.793, a moment of inertia of about 0.448 oz-in<sup>2</sup>, a drop rebound (based on a 100 inches drop) of about 76 inches, and a Shore D (peak) hardness of about 40 (measured on a 0.130 inch thick plaque of MP 10000). The painted ball scuff resistance rating was a 3, showing minimal groove line cuts and lifting. The cut resistance ranking was a 1, showing little or virtually no signs of denting or cutting. These scuff and cut results, as well as those for Example 3 as follows, were obtained using the scuff and cut procedures described in the protocols below. It is noted that the scuff and cut results disclosed in Example 1 were obtained using the procedures defined above Example 1.

#### **Scuff Resistance Procedure**

1. Used the Miyamae mechanical driving machine, with the club described below mounted in the machine.
2. Club: Maltby Logic Pro Tour sand wedge, with box (square) grooves cut to .025 inch wide (No post sandblasting - "worst case" groove type).
3. Clubhead speed: 58 mph.
4. Each ball was hit three times, alternating ball types after every hit. The clubface was brushed clean after each hit to ensure consistent groove contact.
5. The balls were subjectively ranked from 1 to 6, 1 being the best (showing little or no visible damage), 6 being the worst (showing gross amounts of groove cutting, lifting, and peeling damage).

### Cut Resistance Procedure

1. Used an in-house, Spalding-made guillotine device. The device consisted of a 5 lb. (approx.) strike plate positioned approx. 40.5 inches (full height) above the golf ball. The strike surface was approx. 1.5 inch wide, by 0.125 inch thick, possessing tapered sides and a notched section in the middle of the strike surface. The weighted strike plate was allowed to drop by the force of gravity alone onto the golf ball.
2. Each ball was struck three times.
3. The balls were subjectively ranked from 1 to 6, 1 being the best (showing little or no visible damage), 6 being the worst (showing a clean cut through the cover material).

### Example 3

A polybutadiene golf ball center having a diameter of 1.51 inches, a PGA compression of about 42, and a coefficient of restitution (COR) of about 0.786 was obtained. A 0.050 inch thick mantle layer was then injection molded over the center, made from a high acid thermoplastic ionomer material. The mantled core diameter was 1.61 inches, its PGA compression was about 73, and its COR was about 0.810. A dimpled cover having a thickness of about 0.035 inches was reaction injection molded over the mantled core. The cover was comprised of Bayer's Bayflex<sup>®</sup> MP 10000 resin. The setting time of the mixed resin was about 4.5 seconds and the mold release time was about 20 seconds. The isocyanate tank temperature was about 115°F and the polyol tank temperature was about 138°F. The mold temperature was about 156°F. The resulting ball, after painting, had a pole diameter of about 1.6896 inches, an equator diameter of about 1.6900 inches, a weight of about 45.68 grams, a PGA compression of about 79, a COR of about 0.799, a moment of inertia of about 0.451 oz-in<sup>2</sup>, a drop rebound (based on a 100 inches drop) of about 78 inches, and a Shore D (peak) hardness of about 40 (measured on a 0.130 inch thick plaque of MP 10000). The painted ball scuff resistance rating was a 3, showing minimal groove line cuts and lifting. The cut resistance ranking was a 1, showing

little or virtually no signs of denting or cutting. The cut and scuff resistance procedures used to obtain the results in Example 3 are disclosed in Example 2.

#### **Example 4 (Prophetic)**

5           A golf ball core formed from high cis polybutadiene, zinc diacrylate, zinc oxide, zinc stearate, and peroxide initiator is obtained. The core has a diameter of 1.49 inches.

          The core is covered with a 0.04 inch thick mantle layer of RIM polyurethane which has a plaque Shore D hardness of 58, namely BAYFLEX®  
10   110-50 unfilled (Bayer Corp.). The mantle layer is covered with a 0.055 inch thick dimpled outer cover layer of IOTEK® 8000, 7510 and 7030, and a whitener package. The formulation and properties of the golf ball are shown below in Table 3.

#### **Example 5 (Prophetic)**

15           A golf ball core formed from high-cis polybutadiene, zinc diacrylate, zinc oxide, zinc stearate and peroxide imitator is obtained. The core has a diameter of 1.49 inches.

          The core is covered with a 0.040 inch thick mantle layer of RIM  
20   polyurethane having a plaque Shore A hardness of about 90, namely BAYFLEX® MP 10000 unfilled (Bayer Corp.). The mantle layer is covered with a 0.055 inch thick dimpled outer cover layer of Ex 1006 and 1007 (ExxonMobil Corp.) and IOTEK® 7030 (ExxonMobil Corp.). The formulations and properties of the golf ball are shown below in Table 3.

#### **Example 6 (Prophetic)**

25           A golf ball core formed from high-cis polybutadiene, zinc diacrylate, zinc oxide, zinc stearate, and peroxide initiator is obtained. The core has a diameter of 1.49 inches.

30           The core is covered with a 0.055 inch thick mantle layer of IOTEK® 1002 and 1003 (ExxonMobil Corp.). The mantle layer is covered with a 0.04

inch thick dimpled outer cover layer of RIM BAYFLEX® MP10000 unfilled (Bayer Corp.). The formulation and properties of the golf ball are shown below in Table 3.

5

#### **Example 7 (Prophetic)**

A golf ball core having a diameter of 1.42 inches is formed from an elastomeric unfilled RIM polyurethane (BAYFLEX® MP10000, Bayer Corp.). The core is covered with a 0.08 inch thick injection-molded mantle layer of 50 parts by weight IOTEK® 1002 and 50 parts by weight IOTEK® 1003. The mantle layer is covered with a 0.050 inch thick injection-molded outer cover layer of Ex 1006, Ex 1007, IOTEK® 7030, and whitener. The formulation and properties of the golf ball are shown below in Table 5.

15

#### **Example 8 (Prophetic)**

A two-piece golf ball having a core with a diameter of 1.560 inches and a cover of 0.060 inches may be formed. The core comprises polybutadiene, zinc diacrylate (ZDA), and zinc oxide. The cover comprises an elastomeric unfilled RIM polyurethane (BAYFLEX® MP10000, from Bayer Corp.).

**TABLE 3**

Chemical Component	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
<b>Core Data</b>						
Size	1.48"	1.51"	1.49"	1.49"	1.49"	1.42"
Type						
Polybutadiene	Y	Y	Y	Y	Y	—
RIM Polyurethane			—	—	—	Y
<b>Inner Cover Layer</b>	<b>Example 2</b>	<b>Example 3</b>	<b>Example 4</b>	<b>Example 5</b>	<b>Example 6</b>	<b>Example 7</b>
Size	1.58"	1.61"	1.57"	1.57"	1.57"	1.58"
Weight	38g	40g	38g	—	38g	—
Thickness	0.50"	.050"	0.040"	0.040"	0.055"	0.080"
<b>Outer Cover Layer</b>	<b>Example 2</b>	<b>Example 3</b>	<b>Example 4</b>	<b>Example 5</b>	<b>Example 6</b>	<b>Example 7</b>
Hardness (Shore A or D)	68D	68D	58D plaque	90A plaque	70D	70D
Composition (wt %)						

IOTEK® 1002			---	---	50	50
IOTEK® 1003			---	---	50	50
BAYFLEX® 110-50 unfilled			100	---	---	---
BAYFLEX® MP 10000			---	100	---	---
8140 - SURLYN®	50	50				
6120 - SURLYN®		50				
Hardness (Shore A or D)	40D plaque	40D plaque	57D	64D	90A plaque	64D
Thickness	.050"	.035"	0.055"	0.055"	0.040"	0.050"
Composition (wt%)						
BAYFLEX® MP 10000	100	100	---	---	100	---
Exxon 1006			---	46.4	---	46.4
Exxon 1007			---	46.4	---	46.4
IOTEK® 8000			33.8%	---	---	---
IOTEK® 7510			58.9%	---	---	---
IOTEK® 7030			7.3	7.2	---	7.2
Whitener Package						
Unitane™ 0-110 (phr)			2.3	2.3	2.3	2.3
EASTOBRITE® OB1 (phr)			0.025	0.025	0.025	0.025
Ultra Marine Blue™ (phr)			0.004	0.004	0.004	0.004
Final Ball Data						
Size	1.688	1.690	1.68"	1.68"	1.68"	1.68"
Weight	45.6g	45.7g	45.5g	45.5g	45.5g	45.5g
COR (X 1000)	793	799	760-830	760-830	760-830	760-830
6120 - SURLYN®	50	50				

Note: The flex modulus of Bayer's MP BAYFLEX® 10000 in accordance with ASTM® test D790, at 23°C, is 10,000 psi (10 kpsi.).

5

### **Example 9 (Prophetic)**

A polybutadiene golf ball core having a diameter of about 1.545 inches is obtained. The golf ball core is formed from high-cis polybutadiene, zinc diacrylate, zinc oxide, zinc stearate, and a peroxide initiator.

10

The core is encapsulated with a dimpled cover having a thickness of about 0.0675 inches. The cover comprises a polyisocyanate copolymer consisting of a blend of toluene diisocyanate (TDI) and hexamethylene diisocyanate (HDI) and a reactant such as polyol. Such a polyisocyanate

copolymer is sold under the trademark DESMODUR® HL by Bayer Corporation, Pittsburgh, Pennsylvania. The polyisocyanate copolymer and reactant are chemically reacted to form a reaction mixture adapted for reaction injection molding (RIM). The reaction mixture is molded about the polybutadiene core to  
5 form a polyurethane covered golf ball.

#### Example 10 (Prophetic)

A golf ball core is formed comprising a polyisocyanate copolymer consisting of a blend of toluene diisocyanate (TDI) and hexamethylene diisocyanate (HDI) and a reactant, such as a polyol. The golf ball core is  
10 approximately 1.545 inches in diameter.

The core is then covered by an ionomer resin blend to form a cover having a thickness of 0.0675 inches. The resulting ball is approximately 1.68 inches in diameter.

15 The foregoing description is, at present, considered to be the preferred embodiments of the present invention. However, it is contemplated that various changes and modifications apparent to those skilled in the art, may be made without departing from the present invention. Therefore, the foregoing description is intended to cover all such changes and modifications  
20 encompassed within the spirit and scope of the present invention, including all equivalent aspects.